

## Planktonic desmids of three Amazonian systems (Lake Batata, Lake Mussurá and Trombetas River), Pará, Brazil

by

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### Abstract

Forty-eight taxa of planktonic desmids were recorded in 319 samples taken during one year from Lakes Batata and Mussurá and Trombetas River, State of Pará, Brazil. Thirty-eight of these are described and 33 illustrated. *Staurodesmus*, *Staurastrum* and *Cosmarium* were represented by more species than were other genera. The importance of desmids in Amazonian waters, previously documented in literature, is confirmed by the present study.

**Keywords:** Desmids, plankton, taxonomy, Amazonia.

### Resumo

Desmídias planctônicas de três ambientes amazônicos (Lago Batata, Lago Mussurá e Rio Trombetas), Pará, Brasil.

São apresentados 48 táxons de desmídias planctônicas registradas em 319 amostras coletadas durante um ano no lago Batata, lago Mussurá e rio Trombetas, Pará, Brasil, 38 dos quais são descritos e 33 ilustrados. *Staurodesmus*, *Staurastrum* e *Cosmarium* foram os gêneros com maior número de espécies. A importância das desmídias, registrada em literatura, para ambientes amazônicos é aqui confirmada.

## Introduction

The desmids have been indicated in the literature as one of the most important algal groups, with regard to species richness, in Amazonian ecosystems. This importance is demonstrated by the 313 new species and varieties of desmids, of a total of 390 new taxa described for Amazonia (UHERKÓVICH 1984). Additionally, 20 % of the 70 works on Amazonian algae have treated desmids exclusively (GRÖNBLAD 1945; PRESCOTT 1957; FÖRSTER 1963, 1964, 1966, 1974; SCOTT et al. 1965; MARTINS 1980, 1982, 1986a, 1986b; LOPES 1992; BITTENCOURT-OLIVEIRA 1993). Other taxonomic articles include desmids together with other algae (PALAMAR-MORDVINTSEVA & TSARENKO 1990; THOMASSON 1955, 1971, 1977; UHERKÓVICH 1976, 1981; UHERKÓVICH & FRANKEN 1980). Lists of algae including desmids are found in taxonomic (DICKIE 1881) as well as ecological studies (BRAUN 1952; UHERKÓVICH & SCHMIDT 1974; UHERKÓVICH & RAI 1979; MAGRIN 1993).

Studies of the phytoplankton of Lakes Batata and Mussurá and the Trombetas River have treated different aspects, including the taxonomy of the component species (HUSZAR 1996) as well as population structure and dynamics (HUSZAR 1994). The desmids, also considered as a biological group (MARGALEF 1983; BROOK 1981), dominate in biomass in the study area. This dominance is explainable by their adaptations to turbulent acid environments, by the low rate of herbivorous predation on the dominant microplanktonic desmids, and because these are k-selected species adapted to low nutrient levels, chiefly phosphorus (HUSZAR 1994). In this context, the aim of the present study is to inventory the planktonic desmids of these systems.

## Material and methods

Near Porto Trombetas in the Municipality of Oriximiná, State of Pará (Fig. 1), Lakes Batata (at 56°14' to 56°00'W, 1°28' to 1°33'S) and Mussurá (56°18' to 56°19'W, 1°26' to 1°29'S) are located on the right and left banks of the Trombetas River, respectively.

Lake Batata, 29,5 km<sup>2</sup> in area, is permanently connected to the Trombetas River, and during periods of high flow the river waters can rise over the dike which separates the lake from the river. Lake Mussurá, with area about 7.7 km<sup>2</sup> and a preserved lakeshore, is also permanently connected to the Trombetas River through its outflow.

The waters of both habitats (Tab. 1) are characterized by low values of electrical conductivity, pH, alkalinity and soluble reactive phosphorus (HUSZAR 1994).

From 1979 to 1989, bauxite tailings generated by the mining operations of the company Mineração Rio do Norte S.A. were discharged into the west part of Lake Batata. These tailings eventually covered about 30 % of the lake area, measured during the high water stage (ROLAND & ESTEVES 1993) and about 20 %, measured during low water (PANOSSO 1993).

The present study is based on a total of 319 samples collected every three months at 15 sampling stations, 2 located in the Trombetas River, 11 in Lake Batata and 2 in Lake Mussurá; and weekly at 2 stations in Lake Batata, one in the unimpacted ("natural") area, and the other in the area impacted by tailings. The tri-monthly collections were made at different depths at four stages of the Trombetas River hydrological cycle: drowdown water (September 1988), low water (December 1988), filling water (March 1989) and high water (June 1989). During the period 04/Sep/88 to 05/Oct/89, subsurface samples were taken weekly from Lake Batata (at Stations 8 and 10).

Subsurface samples were collected by filling bottles directly with water and the rest were taken with a Van Dorn bottle. Both types were fixed in acetic Lugol's solution (VOLLENWEIDER 1974). In addition

to quantitative samples (HUSZAR 1994), live samples collected with a 25 µm, mesh net and samples fixed in Transeau's solution were also taken in order to identify populations. These last were deposited in the Herbarium of the Museu Nacional (R), Universidade Federal do Rio de Janeiro. The populations were examined using a Zeiss microscope, and identified by analysis of the morphological and morphometric characteristics of the vegetative and reproductive phases.

## Results

Thirty-eight taxa of desmids were identified to infrageneric level, giving brief descriptions, illustrations and ranges of their dimensions. In Table 2 are listed all 48 desmid taxa recorded during the study, including 10 identified only to genus.

Similarity to other phytoplankton algae of the systems studied, desmids are characterized by small size, if their degree of variation and mean linear dimensions are compared with data established from the literature (HUSZAR 1996). The low water conductivity in the systems studied indicates reduced content of dissolved salts, for example soluble reactive phosphorus. The hypothesis suggested is that the small size of the organisms, and consequently the higher surface/volume ratio, is a strategy to optimize absorption of scarce nutrients (HUSZAR 1994).

1. *Actinotaenium perminutum* (G.S. WEST) TEILING ex RUZICKA & POUZAR (Pl. I, Fig. 1)

Folia geobot. phytotax. 13: 56, 1978.

Cells 1.4-1.6 times longer than wide, guitar-shaped. Cell length 11.0-11.5, width 7.1-8.2, isthmus 6.2-7.7 µm.

2. *Closterium gracile* (BRÉBISSEON) ex RALFS (Pl. I, Fig. 10)  
Brit. Desm., p. 221, 1848.

Cells 42-73 times longer than wide, dorsal and ventral margins parallel, apices curved. Cell length 250.0-343.2, width 3.5-8.1 µm.

3. *Cosmarium abbreviatum* RACIBORSKI  
Akad. Umiej. W. Krakow 10: 83, pl. 10, fig. 13, 1885.

Cells as long as wide; semicells 6-angled, angles rounded. Cell length 12.0-13.0, width 11.0-13.0, isthmus 5.0 µm.

4. *Cosmarium arctoum* NORDSTEDT (Pl. I, Fig. 2)  
Öfvers. K. Vetensk. Akad. Förh. 1875(6): 28, pl. 7, fig. 22, 1875.

Cells ca. 1.3 times longer than wide, subrectangular; semicells trapezoidal. Cell length 6.0-7.9, width 4.7-6.0, isthmus 4.2-5.7 µm.

5. *Cosmarium contractum* KIRCHNER (Pl. I, Fig. 3)  
In: COHN's Kryptog Flora Schlesiens V. 2, part 1, p. 47, 1878.

Cells 1.4-2.1 times longer than wide, semicells semicircular. Cell length 18.2-42.2, width 13.4-20.5, isthmus 4.3-4.8 µm.

6. *Cosmarium pseudotaxichondrum* NORDSTEDT var. *longii* (TAYLOR) SCOTT (Pl. I, Fig. 4)

In: SCOTT, GRÖNBLAD & CROASDALE. Acta bot. fenn. 69: 46, pl. 8, fig. 130, 1965.

Cells 1.4 times wider than long; semicells trapeziform, poles rounded, frontal side granulate. Cell length 14.5-19.4, width 14.5-20.5, isthmus 2.4-3.1 µm.

7. *Cosmarium pusillum* (BRÉBISSEON) ARCHER (Pl. I, Fig. 6)

In: PRITCHARD, Hist. Infusor. p. 731, 1861.

Cells 1.0-1.3 times longer than wide; semicells trapeziform, lateral margins convex, apices retuse. Cell length 10.0-10.5, width 7.5-10.6, isthmus 5.2-6.5  $\mu\text{m}$ .

8. *Cosmarium sphagnicolum* WEST & WEST var. *apertum* (SKUJA) FÖRSTER (Pl. I, Fig. 7)

Algol. Stud. 28: 242, 1981.

Cells 1.1 times longer than wide; semicells 6-angled, upper angles with 1 papilla, apices retuse. Cell length 7.4-8.6, width 6.7-9.2, isthmus 2.9-3.9  $\mu\text{m}$ .

9. *Cosmarium tinctum* RALFS var. *subretusum* MESSIKOMMER (Pl. I, Fig. 5)  
Beitr. geobot. Landes. Schweiz 24: 145, pl. 5, fig. 5, 1942.

10. *Cosmarium trilobulatum* REINSCH var. *minutum* FÖRSTER  
Revue algol. New ser. 7(1): 77, pl. 5, fig. 9, 1963.

Cells 1.0-1.5 times longer than wide; semicells trilobate, angles rounded, apices retuse. Cell length 7.3-9.7, width 4.8-9.7, isthmus 5.4-5.5  $\mu\text{m}$ .

11. *Euastrum ornans* FÖRSTER ex FÖRSTER 1981 (Pl. I, Fig. 9)  
Algol. Stud. 28: 230, 1981.

Cells 1.0-1.1 times longer than wide; semicells trapeziform, apices biundulate, basal angles with 1 spine, apical angles with divergent spines. Cell length 24.2-27.9, width 24.0-32.1, isthmus 5.0-5.7  $\mu\text{m}$ .

12. *Gonatozygon pilosum* WOLLE  
Bull. Torrey bot. Club 9(1): 27, pl. 13, fig. 16, 1882.

Cells ca. 55 times longer than wide, cylindrical; cell wall with hairlike spines. Cell length ca. 138.0, width ca. 2.5  $\mu\text{m}$ .

13. *Mesotaenium chlamydosporum* DE BARY (Pl. I, Fig. 13)  
Untersuch. Fam. Conj. p. 75, pl. 7-D, 1858.

Cells 2.0-2.2 times longer than wide, generally elliptical, rarely ovate. Cell length 11.0-24.2, width 5.0-12.1  $\mu\text{m}$ .

14. *Mesotaenium chlamydosporum* DE BARY var. *violascens* (DE BARY) KRIEGER (Pl. I, Fig. 8)  
Kryptog Flora Schweiz, V. 13(1): p. 201, pl. 14, figs. 10 and 11, 1937.

Cells 1.3-1.5 times longer than wide, generally elliptical, rarely ovate. Cell length 7.3-10.5, width 4.8-7.3  $\mu\text{m}$ .

15. *Pleurotaenium tenuissimum* (GRÖNBLAD & CROASDALE) FÖRSTER (Pl. I, Fig. 12)  
Arch. Hydrobiol. Suppl. 60(3): 246, 1981.

Cells 27-37 times longer than wide, fusiform, apices with 2 papillae in frontal view. Cell length 146.0-220.0, width 4.8-8.1  $\mu\text{m}$ .

16. *Pleurotaenium trabecula* (EHRENBERG) ex NÄGELI (Pl. I, Fig. 11)  
Gatt. einzell Algen p. 104, 1849.

Cells 11-14 times longer than wide, cylindrical; semicells with inflated base. Cell length 270.0-570.0, width 22.0-41.8, width of apices 10.0-27.0, isthmus 16.0-41.8  $\mu\text{m}$ .

17. *Stauroastrum brachiatum* RALFS (Pl. III, Fig. 1)  
Brit. Desm. p. 131, fig. 9, 1848.

Cells 1.0-1.3 times longer than wide; semicells trapeziform, lateral margins prolonged in 3 smooth divergent processes, each with 2-3 spines at extremity. Cell length including processes 21.0-37.9, width including processes 20.0-38.5, isthmus 4.2-6.3  $\mu\text{m}$ .

18. *Stauroastrum leptocladum* NORDTSTEDT var. *cornutum* WILLE (Pl. IV, Fig. 2)

Bih. K. svenska Vetensk. Akad. Handl. 8(18): 19, pl. 1, fig. 39, 1884.

Cells 1.5-2.4 times wider than long; semicells subcampanulate, apical margin with 2 submarginal spines, pointed in opposite directions, lateral margins elongated in 2 subparallel crenulate processes, transverse row of pre-isthmal granules. Cell length including processes 42.9-71.0, width including processes 67.0-107.4, isthmus 6.0-8.4  $\mu\text{m}$ .

19. *Staurastrum longipes* (NORDSTEDT) TEILING (Pl. V, Fig. 1)

Bot. Notiser 1946(1): 80, fig. 23, 1946.

Cells 1.1-1.3 times longer than wide; semicells trapeziform, lateral margins elongated in 3 divergent crenulate processes. Cell length including processes 55.7-82.1, width including processes 56.0-63.1, isthmus 7.4-9.6  $\mu\text{m}$ .

20. *Staurastrum muticum* (BRÉBISSEON) RALFS (Pl. III, Fig. 3)

Brit. Desm. p. 125, pl. 21, fig. 4, pl. 24, fig. 13, 1848.

Cells 1.2-1.5 times longer than wide; semicells oblong, cell wall smooth, triangular in apical view. Cell length 18.4-21.9, width 12.1-18.4, isthmus 6.0-8.6  $\mu\text{m}$ .

21. *Staurastrum octangulare* GRÖNBLAD (Pl. III, Fig. 4)

Acta Soc. Sci. fenn. New ser. B 2(6): 28, fig. 249, 1945.

Cells 1.3-2.3 times longer than wide; semicells elliptical, apical margin with 3 short smooth processes, with 2 teeth at extremity, lateral margins with 6 short smooth divergent processes, each with 2 teeth at extremity. Cell length including processes 21.5-38.8, width including processes 15.7-16.9, isthmus ca. 5.7  $\mu\text{m}$ .

22. *Staurastrum pseudotetracerum* (NORDSTEDT) WEST & WEST (Pl. III, Fig. 2)

Trans. Linn. Soc. London, Ser. Bot. II, 5(5): 79, pl. 8, fig. 39, 1895.

Cells 1.1-1.3 times wider than long; semicells trapeziform, lateral margins prolonged in 3 divergent crenulate processes. Cell length including processes 14.7-23.0, width including processes 16.9-27.9, isthmus 3.9-6.0  $\mu\text{m}$ .

23. *Staurastrum quadrinotatum* GRÖNBLAD (Pl. IV, Fig. 1)

Acta Soc. Sci. fenn. New Ser. B 2(6): 30, fig. 258, 1945.

Cells 1.6 times wider than long; semicells trapeziform, apex tumescent, with 4 spines opposed 2 to 2, lateral margins prolonged in 2 divergent denticulate processes. Cell length including processes 58.6-70.0, width including processes 95.0-110.0, isthmus 5.5-6.2  $\mu\text{m}$ .

24. *Staurastrum rotula* NORDSTEDT (Pl. II, Fig. 1)

Vidensk. Meddr. dansk naturh. Foren 1869: 227, pl. 4, fig. 38, 1869.

Cells 2.4-2.7 times wider than long; semicells subtrapeziform, convex poles with 2 visible spines, lateral margins prolonged in 5-8 subparallel denticulate processes, each with 3 teeth on extremity. Cell length including processes 27.4-34.2, width including processes 68.4-81.6, isthmus 6.3-9.1  $\mu\text{m}$ .

25. *Staurastrum subamericanum* GRÖNBLAD (Pl. IV, Fig. 3)

Acta Soc. Sci. fenn. New ser. B 2(6): 30, fig. 277, 1945.

Cells 2.0-4.0 times wider than long; semicells trapeziform, poles slightly convex, crenulate, lateral margins prolonged in 2 divergent denticulate processes. Cell length including processes 26.8-54.7, width including processes 98.4-110.8, isthmus 7.9-10.0  $\mu\text{m}$ .

26. *Staurastrum tetracerum* (KÜTZING) RALFS var. *tortum* (TEILING) BORGE (Pl. III, Fig. 5)

Sjön Jaberna Fauna och Flora 4: 22, pl. 2, fig. 22, 1921.

Cells 1.2-1.5 times wider than long; semicells trapeziform, twisted; lateral margins prolonged in 2 divergent denticulate processes. Cell length including processes 18.4-22.6, width including processes 21.6-34.0, isthmus 3.0-6.8  $\mu\text{m}$ .

27. *Staurodesmus controversus* (W. WEST) TEILING  
Ark. Bot. 6(11): 504, pl. 4, fig. 14, 1967.

Cells 1.3-1.5 times longer than wide; semicells trapeziform, apical margin slightly convex, each angle with 1 short spine, divergent; elliptical in apical view. Cell length including spines 7.3-9.0, width including spines 4.8-7.0, isthmus ca. 3.0  $\mu\text{m}$ .

28. *Staurodesmus crassus* (WEST & WEST) FLORIN (Pl. IV, Fig. 4)  
Acta phytogeogr. suec. 37: 138, 1957.

Cells 1.0-1.2 times longer than wide; semicells trapeziform, apical margin straight to slightly convex, each angle with 1 short spine, divergent; elliptical in apical view. Cell length including spines 11.5-16.7, width including spines 13.4-17.6, isthmus 6.5-9.6  $\mu\text{m}$ .

29. *Staurodesmus cuspidatus* (BRÉBISSE) TEILING VAR: *groenbladii* FÖRSTER  
(Pl. V, Fig. 6)  
Amazoniana 2(1/2): 67, pl. 29, fig. 18 and 19, 1969.

Cells 0.9-1.2 times wider than long; semicells trapeziform, apical margin concave, lateral margin elongate, 1 long spine at each angle; triangular in apical view. Cell length including spines 25.3-34.2, width including spines 27.4-30.5, isthmus 5.2-7.2  $\mu\text{m}$ .

30. *Staurodesmus dickiei* (RALFS) LILLIEROTH  
Acta limnol. 3: 264, 1950.

Cells ca. 1.1 times longer than wide, sinus open, acuminate; semicells elliptical, each angle with 1 short spine, convergent; triangular in apical view. Cell length ca. 26.0, width not including spines ca. 23.0, isthmus ca. 8.0  $\mu\text{m}$ .

31. *Staurodesmus glaber* (EHRENBERG) TEILING var. *hirundinella*  
(MESSIKOMMER) TEILING (Pl. V, Fig. 3)  
Ark. Bot. 6(11): 559, pl. 14, figs. 4, 6, 1967.

Cells 1.5-1.8 times wider than long; semicells triangular, apical margin concave, each angle with 1 long spine, convergent, triangular in apical view. Cell length 12.6-19.2, width including spines 18.9-30.7, isthmus 3.7-6.0  $\mu\text{m}$ .

32. *Staurodesmus lobatus* (BÖRGESSEN) BOURRELLY var. *ellipticus* FRITSCH  
& RICH f. *minor* (G.M. SMITH) TEILING (Pl. IV, Fig. 5)  
Ark. Bot. 6(11): 586, pl. 24, fig. 8, 1967.

Cells 1.2-2.0 times longer than wide; semicells oblong, each lateral margin with 1 papilla in median region; oblong in apical view. Cell length 12.0-26.0, width not including papilla 5.7-20.6, isthmus 3.1-7.3  $\mu\text{m}$ .

33. *Staurodesmus mamillatus* (NORDSTEDT) TEILING (Pl. V, Fig. 2)  
Ark. Bot. 6(11): 536, pl. 10, fig. 5, 1967.

Cells 1.6-1.8 times wider than long; semicells triangular, apical margin convex, angles inflated, each with 1 long spine, parallel; isthmus elongated, triangular in apical view. Cell length 21.1-30.5, width including spines 36.3-45.6, isthmus 4.7-5.2  $\mu\text{m}$ .

34. *Staurodesmus phimus* (TURNER) THOMASSON var. *robustus* TEILING (Pl. IV, Fig. 6)  
Ark. Bot. 6(11): 507, pl. 5, fig. 2, 1967.

Cells as long as wide; semicells trapeziform, apical margin concave, each angle with 1 long spine, divergent; elliptical in apical view. Cell length with spines, 14.8-24.9,

width including spines 16.8-25.9, isthmus 5.2-8.2  $\mu\text{m}$ .

35. *Staurodesmus pseudoarthrodesmus* (GRÖNBLAD) TEILING (Pl. V, Fig. 4)  
Ark. Bot. 6(11): 550, pl. 14, fig. 17, 1967.

Cells 2.0-2.5 times longer than wide; semicells subcylindrical, apical margin concave, each angle with 1 long, widely divergent spine; elliptical in apical view. Cell length including spines, 41.6-86.3, width 21.0-34.7, isthmus 4.6-7.4  $\mu\text{m}$ .

36. *Staurodesmus triangularis* (LAGERHEIM) TEILING (Pl. II, Fig. 2)  
Ark. Bot. 6(11): 517, pl. 6, fig. 4, 1967.

Cells 1.9-2.8 times wider than long; semicells trapeziform, apical margin straight or convex, each angle with 1 long spine, parallel or slightly divergent; elliptical in apical view. Cell length 11.5-28.4, width including spines 33.7-53.7, isthmus 4.7-5.3  $\mu\text{m}$ .

37. *Teilingia granulata* (ROY & BISSET) BOURRELLY (Pl. V, Fig. 7)  
Revue algol., New Ser. 7(2): 190, 1964.

Filaments not twisted; cells 1.0-1.2 times longer than wide; semicells oblong, apical margin straight with 2 equidistant mucilaginous granules; lateral margin with 2 granules. Cell length 9.5-10.0, width 7.3-9.7, isthmus 3.0-4.7  $\mu\text{m}$ .

38. *Xanthidium octocorne* (EHRENBERG) RALFS (Pl. V, Fig. 5)  
Brit. Desm. p. 116, pl. 20, fig. 2a-e, 1848.

Cells 1.1-1.7 times longer than wide; semicells subhexagonal, sinus open, rounded; margins concave, 4 angles with long spines. Cell length including spines 22.5-36.0, width including spines 14.5-32.0, isthmus 2.4-5.0  $\mu\text{m}$ .

### Final considerations

In this study, 27 species, 10 varieties and one taxonomic form of desmids were recorded; an additional 10 taxa could not be determined to these taxonomic levels. *Staurodesmus*, *Staurostrum* and *Cosmarium* were the genera with the largest number of species.

The greater degree of expression of the desmids in the aquatic phycological communities of Amazonia, already documented in the literature, was confirmed in the present work. This expression was evidenced not only in their contribution of 20 % of the taxa recorded, as already demonstrated by HUSZAR (1994), but also by the dominance of these algae in the biomass. Desmids dominate in Lake Batata principally during about six months of the year, when the amplitude of the hydrological pulse of the Trombetas River to which the lake is subject is smaller (HUSZAR 1994).

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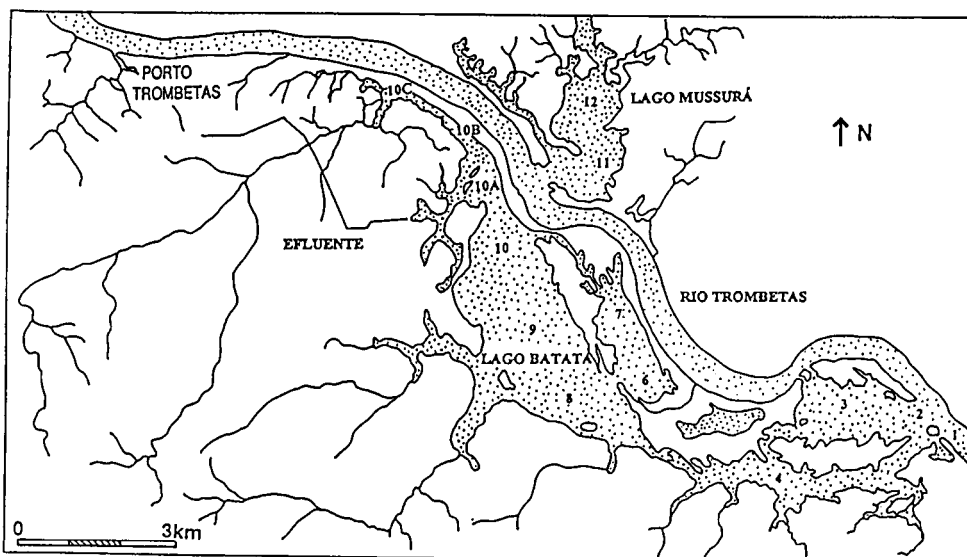
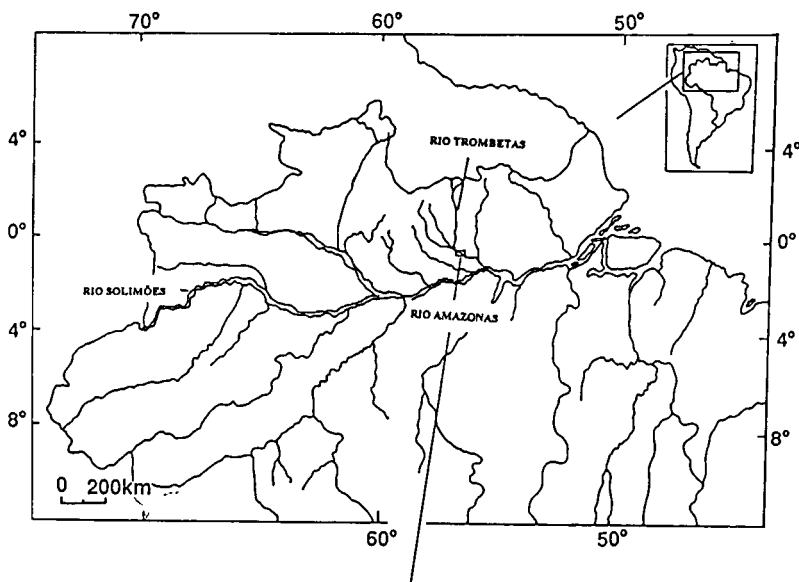


Fig. 1:  
Map of Lake Batata, Lake Mussurá and Trombetas River, showing the sampling stations.

Table 1: Mean values of some abiotic variables of the systems studied.

	Mean	No. of samples
Water transparency (m)	1.3	57
Electrical conductivity ( $\mu\text{S}\cdot\text{cm}^{-2}$ )	12.9	201
Water temperature ( $^{\circ}\text{C}$ )	29.7	201
pH	5.9	201
Alkalinity ( $\text{mEq}\cdot\text{l}^{-1}$ )	0.07	201
Soluble reactive phosphorus ( $\mu\text{g}\cdot\text{l}^{-1}$ )	4.8	201
Nitrate ( $\mu\text{g}\cdot\text{l}^{-1}$ )	40.1	201

Table 2: List of desmid taxa recorded in the three systems studied.

<i>Actinotaenium perminutum</i>	<i>S. longipes</i>
<i>Closterium gracile</i>	<i>S. muticum</i>
<i>Closterium</i> sp.	<i>S. octangulare</i>
<i>Cosmarium abbreviatum</i>	<i>S. pseudotetracerum</i>
<i>C. arctoum</i>	<i>S. quadrinotatum</i>
<i>C. contractum</i>	<i>S. rotula</i>
<i>C. pseudotaxichondrum</i> var. <i>longii</i>	<i>S. subamericanum</i>
<i>C. pusillum</i>	<i>S. tetracerum</i> var. <i>tortum</i>
<i>C. sphagnicolum</i> var. <i>apertum</i>	<i>Staurostrum</i> sp.
<i>C. tinctum</i> var. <i>subretusum</i>	<i>Staurodesmus controversus</i>
<i>C. trilobulatum</i> var. <i>minutum</i>	<i>S. crassus</i>
<i>Cosmarium</i> sp 1	<i>S. cuspidatus</i> var. <i>groenbladii</i>
<i>Cosmarium</i> sp 3	<i>S. dickiei</i>
<i>Cosmarium</i> sp 4	<i>S. glaber</i> var. <i>hirundinella</i>
<i>Euastrum ornans</i>	<i>S. lobatus</i> var. <i>ellipticus</i> f. <i>minor</i>
<i>Gonatozygon pillosum</i>	<i>S. mamillatus</i>
<i>Mesotaenium chlamydosporum</i>	<i>S. phimus</i> var. <i>robustus</i>
<i>M. chlamydosporum</i> var. <i>violascens</i>	<i>S. pseudoarthrodesmus</i>
<i>Mesotaenium</i> sp 1	<i>S. triangularis</i>
<i>Mesotaenium</i> sp 2	<i>Staurodesmus</i> sp 2
<i>Pleurotaenium tenuissimum</i>	<i>Staurodesmus</i> sp 3
<i>P. trabecula</i>	<i>Staurodesmus</i> sp 4
<i>Staurostrum brachiatum</i>	<i>Teilingia granulata</i>
<i>S. leptocladum</i> var. <i>cornutum</i>	<i>Xanthidium octocorne</i>

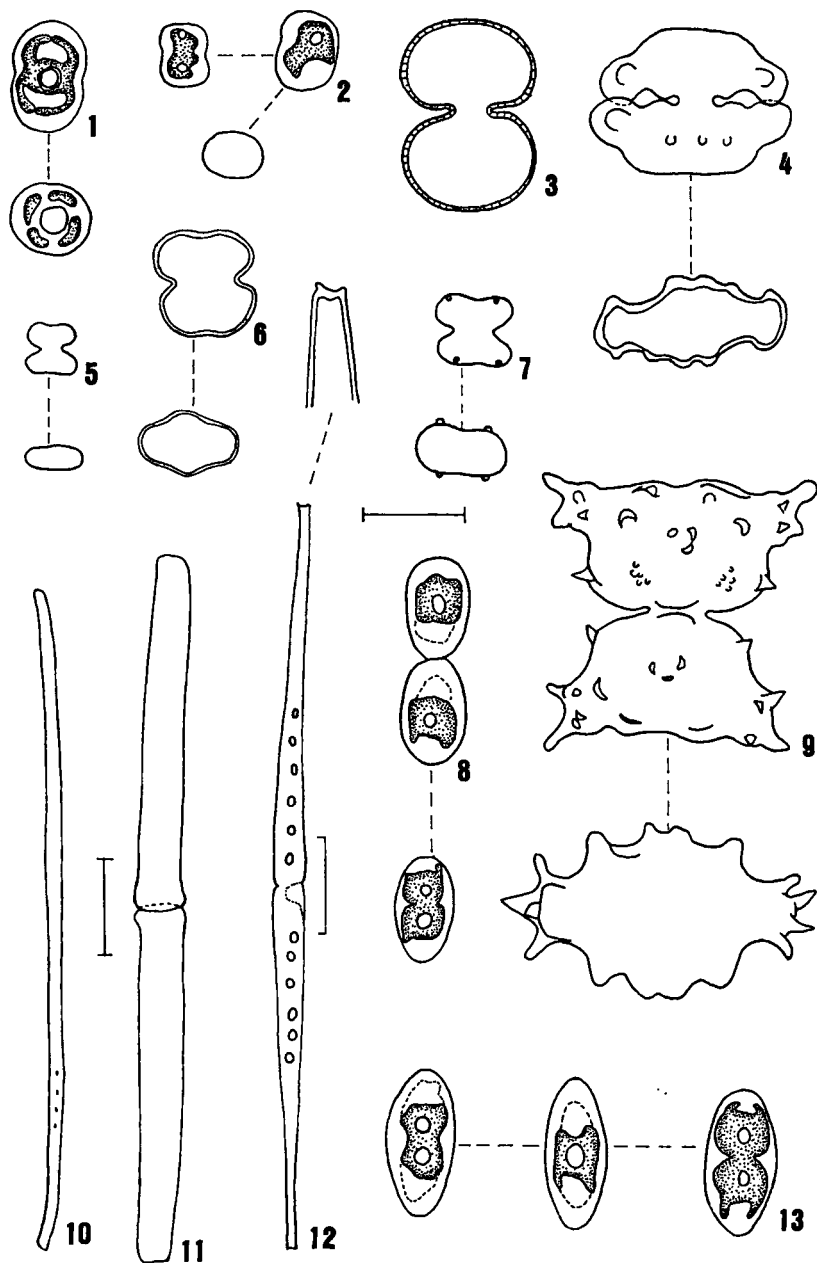


Plate I:

1: *Actinotaenium perminutum*; 2: *Cosmarium arctoum*; 3: *Cosmarium contractum*; 4: *Cosmarium pseudotaxichondrum* var. *longii*; 5: *Cosmarium tinctum* var. *subretusum*; 6: *Cosmarium pusillum*; 7: *Cosmarium sphagnicolum* var. *apertum*; 8: *Mesotaenium chlamydosporum* var. *violascens*; 9: *Euastrum ornans*; 10: *Closterium gracile*; 11: *Pleurotaenium trabecula*; 12: *Pleurotaenium tenuissimum*; 13: *Mesotaenium chlamydosporum*. Scales: Fig. 10 = 50  $\mu$ m; Fig. 12 = 25  $\mu$ m; others = 10  $\mu$ m.

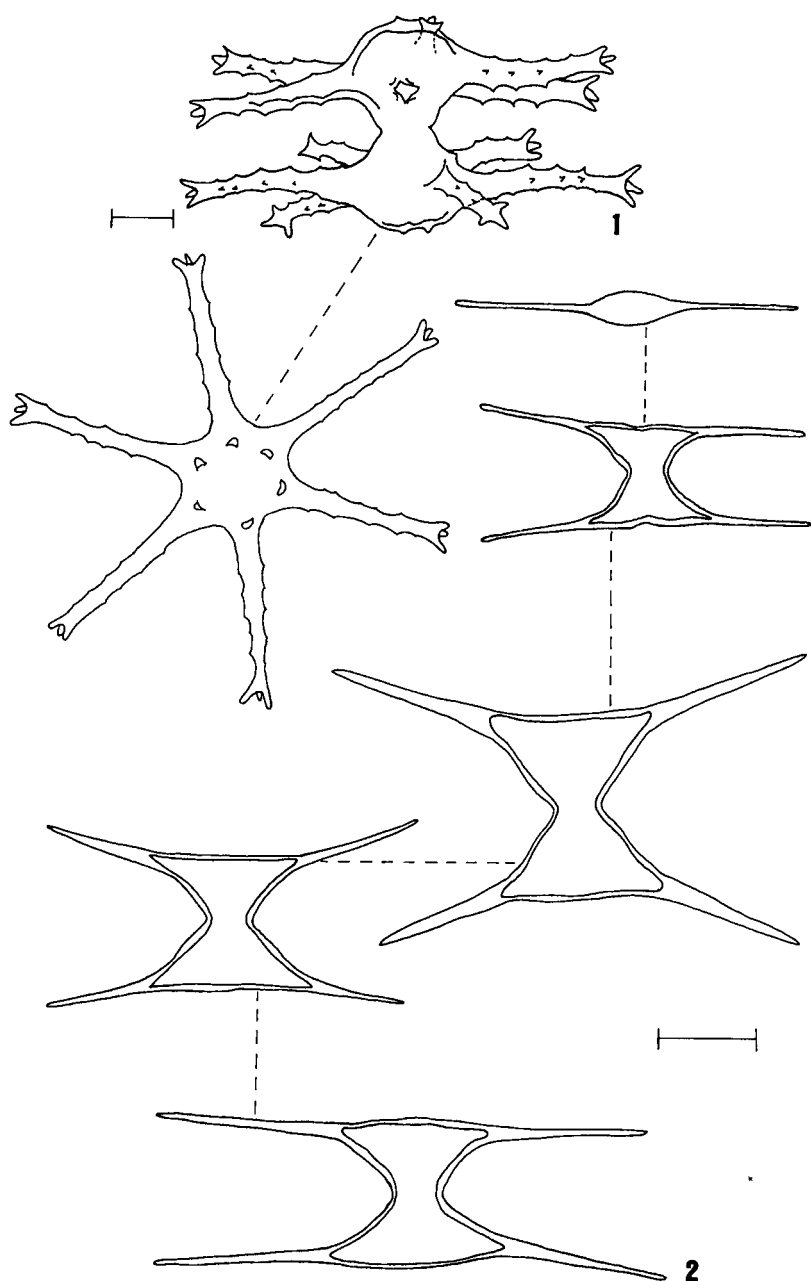


Plate II:

1: *Staurastrum rotula*; 2: *Staurodesmus triangularis*. Scales = 10  $\mu$ m.

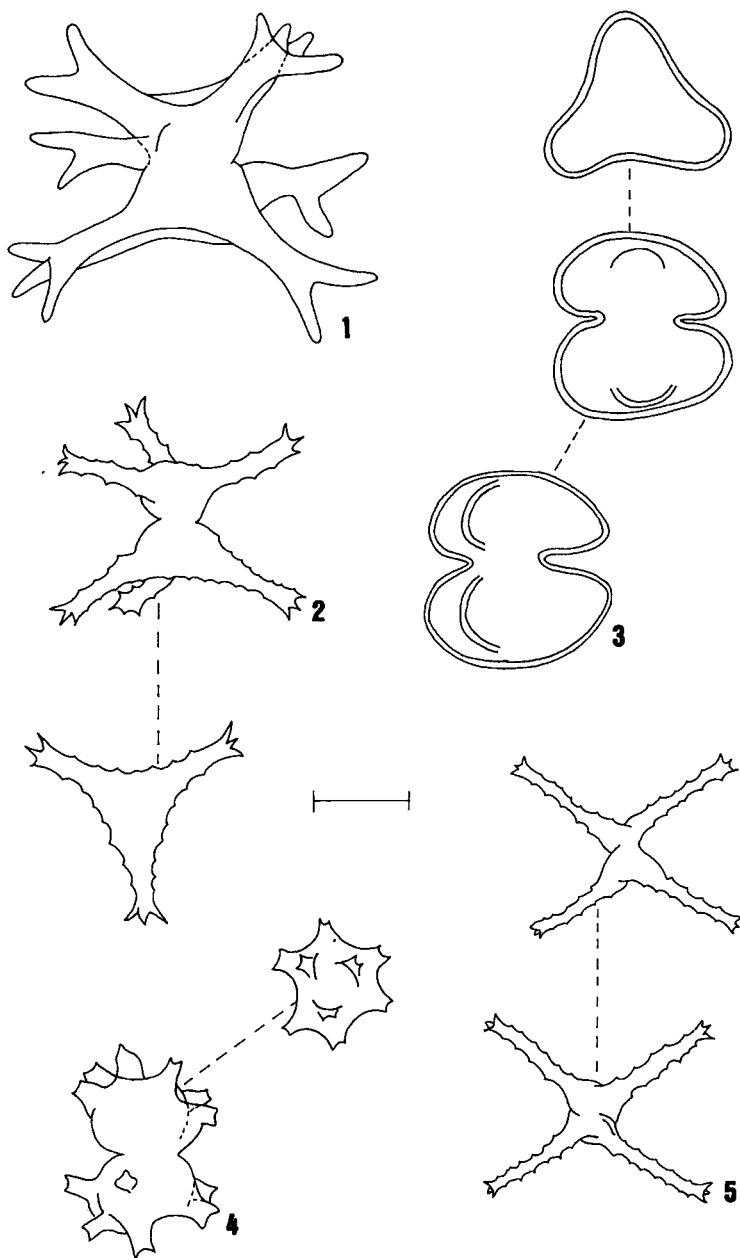


Plate III:

1: *Staurastrum brachiatum*; 2: *Staurastrum pseudotetracerum*; 3: *Staurastrum muticum*; 4: *Staurastrum octangulare*; 5: *Staurastrum tetracerum* var. *tortum*. Scales = 10  $\mu$ m.

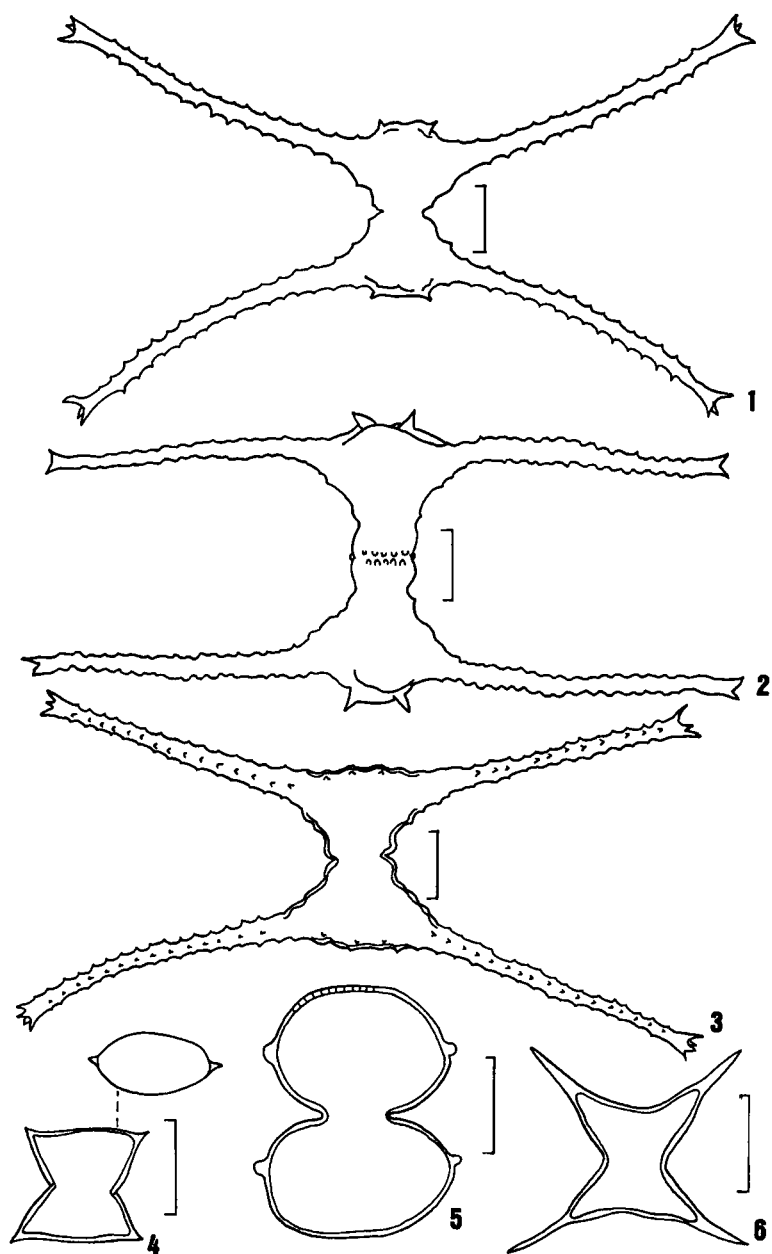


Plate IV:

1: *Staurastrum quadrinotatum*; 2: *Staurastrum leptocladum* var. *cornutum*; 3: *Staurastrum subamericanum*;  
 4: *Staurodesmus crassus*; 5: *Staurodesmus lobatus* var. *ellipticus* f. *minor*; 6: *Staurodesmus phimus* var.  
*robustus*. Scales = 10  $\mu$ m.

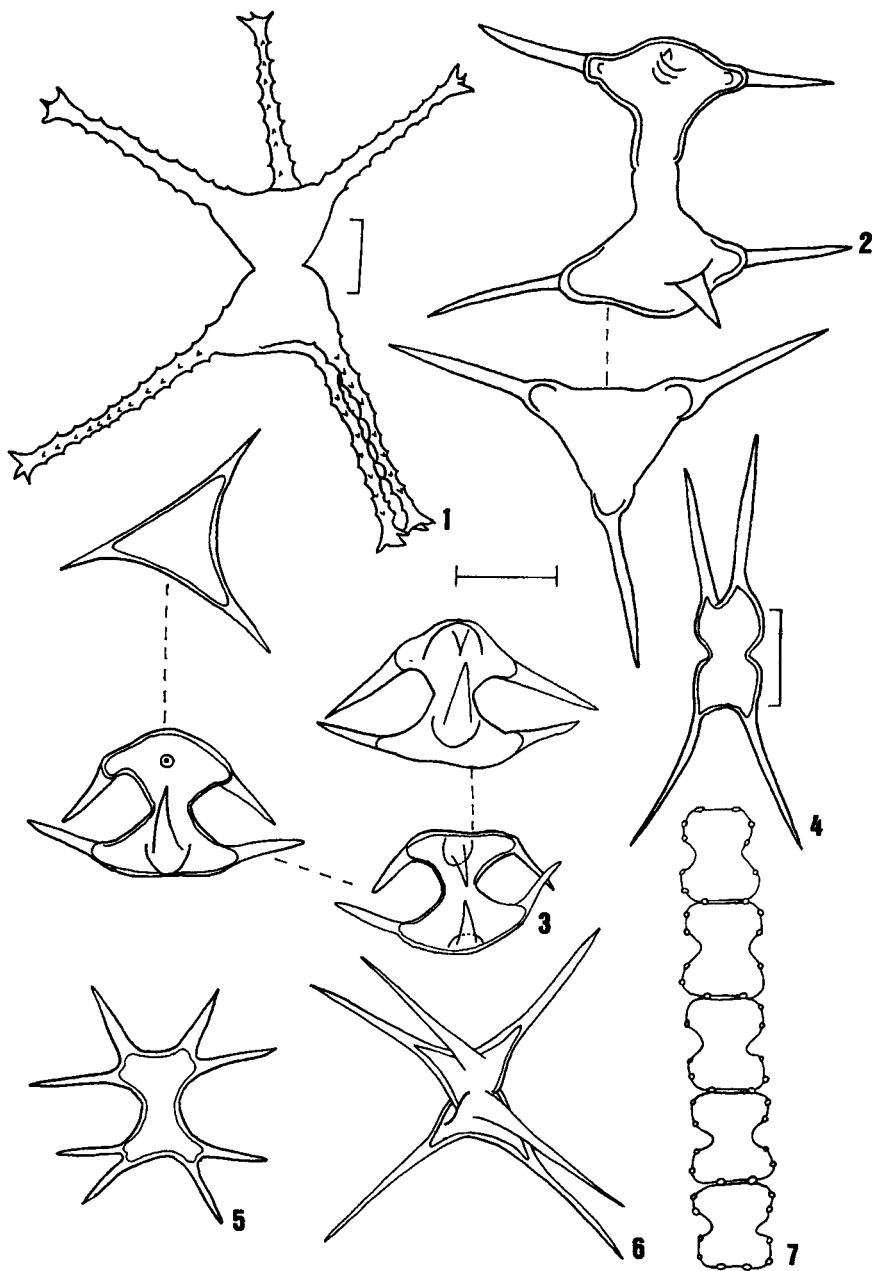


Plate V:

1: *Staurastrum longipes*; 2: *Staurodesmus mamillatus*; 3: *Staurodesmus glaber* var. *hirundinella*; 4: *Staurodesmus pseudoarthrodesmus*; 5: *Xanthidium octocorne*; 6: *Staurodesmus cuspidatus* var. *groenbladii*; 7: *Teilingia granulata*. Scales: Fig. 4 = 20  $\mu\text{m}$ ; others = 10  $\mu\text{m}$ .